# *2. Air Dispersion Modeling*

## *2.1 Air Dispersion Modeling in Risk Assessment: Overview*

The concentration of pollutants in the ambient air is integral to characterizing the airborne exposure pathway and the overall risk assessment process. Pollutant concentrations are required in risk assessment calculations to estimate the cancer risk or hazard indices associated with the emissions of any given facility. Although monitoring of a pollutant provides excellent characterization of its concentrations, it is time consuming, costly and is typically limited to a few receptor locations. Air dispersion modeling has the advantage of being relatively inexpensive and is less time consuming provided that all the model inputs are available. In addition, air dispersion modeling provides greater flexibility in terms of receptor locations, assessment of individual and cumulative source contributions, and characterization of concentration over greater spatial extents. The air dispersion models used in Hot Spots program do not consider chemical reactions. Atmospheric reactions (including photolysis) will decrease atmospheric concentrations for chemicals that react (or photolyze). The air modeling will thus tend to overestimate concentrations for these chemicals. The air pollution control districts evaluate and approve modeling of the emissions from facilities. Application of professional judgment is required throughout the modeling process and the local air district is the final authority on modeling protocols. The guidance that follows is only intended to assist in understanding the process.

Air dispersion modeling requires the execution of the following steps (see Fig 1):

(1) complete an emission inventory of the toxic releases (Section 2.2)

(2) classify the emissions according to source type and source quantity (Section 2.3)

(3) classify the analysis according to terrain (Section 2.4)

(4) determine level of detail for the analysis: refined or screening analysis (Section 2.5)

(5) identify the population exposure(Section 2.6)

(6) determine the receptor locations where impacts need to be analyzed (Section 2.7)

(7) obtain meteorological data (for refined air dispersion modeling only) (Section 2.8)

(8) select an air dispersion model (Section 2.9)

(9) prepare modeling protocol and submit to the local Air District (hereafter referred to as “the District”) (Section 2.14)

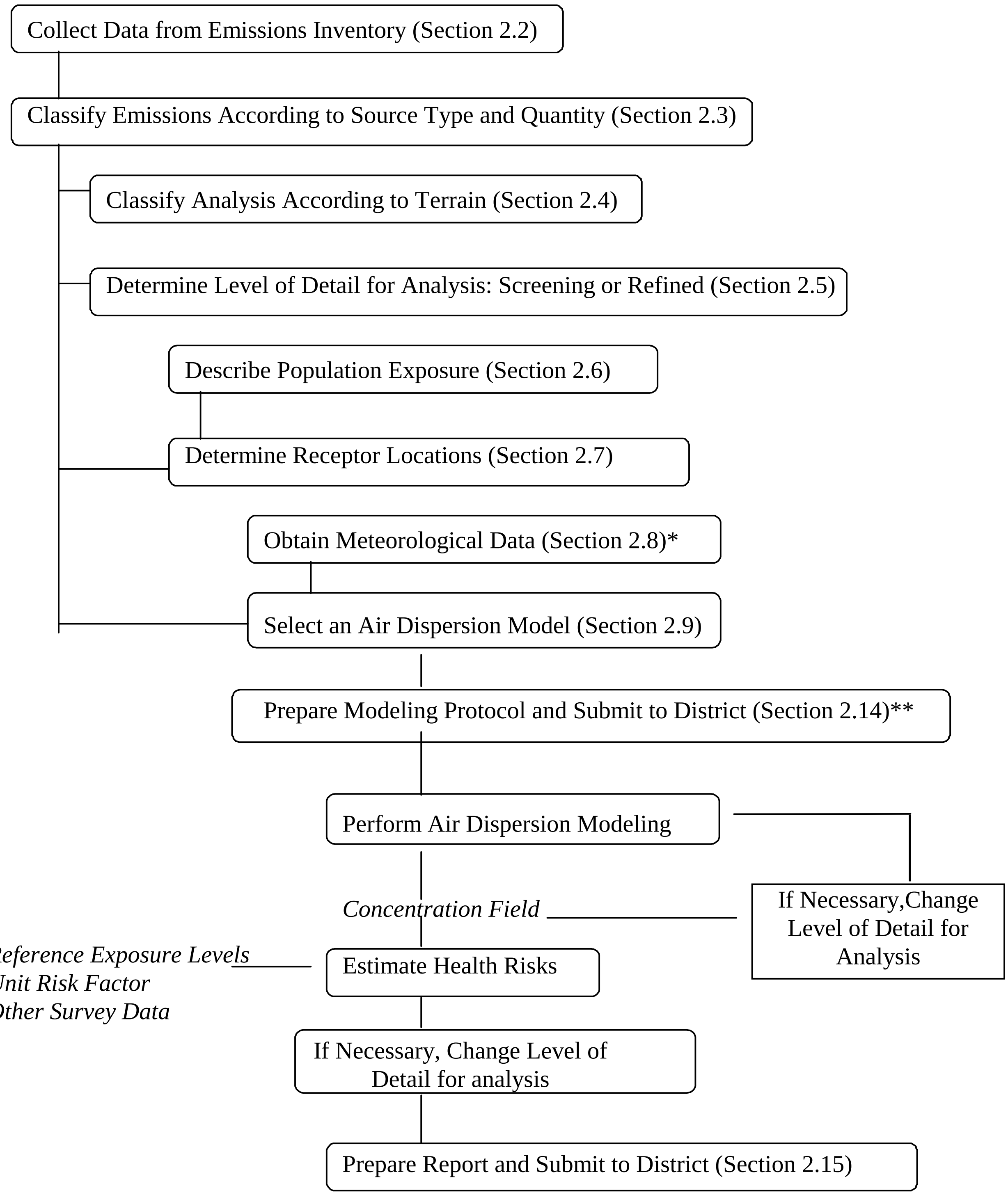
(10) perform an air dispersion analysis

(11) if necessary, redefine the receptor network and return to Step 10

(12) perform risk assessment

(13) if necessary, change from screening to refined model and return to Step 8

**Figure 1. Overview of the Air Dispersion Modeling Process.**




*Some screening models do not require any meteorological data.
** Optional but strongly recommended.

The output of an air dispersion modeling analysis will be a receptor field of concentrations of the pollutant in ambient air. These concentrations in air need to be coupled with reference exposure levels and unit risk factors to estimate the hazard indices and potential carcinogenic risks. It should be noted that in the Air Toxics "Hot Spots" program, facilities model the dispersion of the chemical emitted, and do not model any atmospheric transformations or dispersion of products from such reactions.

## *2.2 Emission Inventories*

The emission information contained in the Emission Inventory Reports ("Inventory Reports") developed under the Air Toxics "Hot Spots" Information and Assessment Act (AB2588), provides data to be used in the risk assessment and in the air dispersion modeling process. The Inventory Reports contain information regarding emission sources, emitted substances, emission rates, emission factors, process rates, and release parameters (area and volume sources may require additional release data generally available in Emissions Inventory reports). This information is developed according to the California Air Resources Board (CARB) Emission Inventory Criteria and Guidelines ("Inventory Guidelines") Regulation[1] and the Emission Inventory Criteria and Guidelines Report ("Inventory Guidelines Report"), which is incorporated by reference into the Regulation.

Use of updated emission information to account for process changes, emission factor changes, material/fuel changes, or shutdown must be approved by the District prior to the submittal of the risk assessment. Ideally, the District review of updated emissions could be completed within the modeling protocol. In addition, it must be stated clearly in the risk assessment if the emission estimates are based on updated or revised emissions (e.g., emission reductions). This section summarizes the requirements that apply to the emission information which is used for Air Toxics "Hot Spots" Act risk assessments.

### *2.2.1 Air Toxics "Hot Spots" Emissions*

#### *2.2.1.1 Substances Emitted*

The risk assessment should identify all substances emitted by the facility which are on the Air Toxics "Hot Spots" Act list of substances (Appendix A I-III, Inventory Guideline Report). The list of substances is compiled by the CARB for the Air Toxics "Hot Spots" Program.

The Inventory Guidelines specify that Inventory Reports must identify and account for all listed substances used, manufactured, formulated or released. Under the regulations, the list is divided into three groups for reporting purposes[2]. For the first group (listed in Appendix A-I of the Inventory Guidelines Report), all emissions must be quantified. For substances in the second group (listed in Appendix A-II of the Inventory Guidelines Report), emissions do not need to be quantified, however, facilities must report whether the substance is used, produced, or otherwise

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[1] Title 17, California Code of Regulations, Sections 93300-93300.5
[2] The most recent amendments became effective July 1, 1997.

present on-site. For the third group (listed in Appendix A-III of the Emissions Inventory Guidelines Report), emissions need not be reported unless the substance is manufactured by the facility. Chemicals or substances in the second and third groups should be listed in a table in the risk assessment.

Facilities that must comply with the Resource Conservation and Recovery Act and Comprehensive Environmental Response, Compensation and Liability Act (RCRA/CERCLA) requirements for risk assessment need to consult the Department of Toxic Substances Control (DTSC) Remedial Project Manager to determine which substances must be evaluated in their risk assessment in addition to the list of "Hot Spots" chemicals. Some RCRA/CERCLA facilities may emit chemicals that are not currently listed under the "Hot Spots" Program.

#### *2.2.1.2 Emission Estimates Used in the Risk Assessment*

The risk assessment must include emission estimates for all substances required to be quantified in the facility's emission inventory report. Specifically, risk assessments should include both annual average emissions and maximum 1-hour emissions for each pollutant. Emissions for each substance must be reported for individual emitting processes associated with unique devices within a facility. Total facility emissions for an individual air contaminant will be the sum of emissions reported, by process, for that facility. Information on daily and annual hours of operation and relative monthly activity must be reported for each emitting process. Devices and emitting processes must be clearly identified and described and must be consistent with those reported in the emissions inventory report.

The risk assessment should include tables that present the emission information (i.e., emission rates for each substance released from each process) in a clear and concise manner. The District may allow the facility operator to base the risk assessment on more current emission estimates than those presented in the previously submitted emission inventory report (i.e., actual enforceable emission reductions realized by the time the risk assessment is submitted to the District). If the District allows the use of more current emission estimates, the District must review and approve the new emissions estimates prior to use in the risk assessment. The risk assessment report must clearly state what emissions are being used and when any reductions became effective. Specifically, a table presenting emission estimates included in the previously submitted emission inventory report as well as those for the risk assessment should be presented. The District should be consulted concerning the specific format for presenting the emission information. A revised emission inventory report must be submitted to the District prior to submitting the risk assessment and forwarded by the District to the CARB, if revised emission data are used.

Facilities that must also comply with RCRA/CERCLA requirements for risk assessments need to consult the DTSC Remedial Project Manager to determine what constitutes appropriate emissions data for use in the risk assessment. Source testing may be required for such facilities even if it is not required under the "Hot Spots" Program. Additional requirements for statistical treatment of source test results may also be imposed by the DTSC on RCRA/CERCLA facilities.

#### *2.2.1.3 Release Parameters*

It is necessary to report how substances are released into the atmosphere. Release parameters (e.g., stack height and inside diameter, stack gas exit velocity, release temperature and emission source location in UTM coordinates) are needed to use air dispersion models. The Inventory Guidelines specify the release parameters that must be reported for each stack, vent, ducted building, exhaust site, or other site of exhaust release. Additional information may be required to characterize releases from non-stack (volume and area) sources, see U.S. EPA dispersion modeling guidelines or specific user's manuals. This information should also be included in the air dispersion portion of the risk assessment. This information must be presented in tables included in the risk assessment. Note that some dimensional units needed for the dispersion model may require conversion from the units reported in the Inventory Report (e.g., degrees K vs. degrees F).

#### *2.2.1.4 Operation Schedule*

The risk assessment should include a discussion of the facility operation schedule and daily emission patterns. Special weekly or seasonal emission patterns may vary and should be discussed. This is especially important in a refined risk assessment. Diurnal emission patterns should match the diurnal dispersion characteristics of the ambient air. In addition, for the purposes of exposure adjustment, the emission schedule and exposure schedule should corroborate any exposure adjustment factors. (For example, no exposure adjustment factor should be made when the worker and the emissions are on a coincident schedule.) Some fugitive emission patterns may be continuous. A table should be included with emission schedule on an hourly and yearly basis.

#### *2.2.1.5 Emission Controls*

The risk assessment should include a description of control equipment, the emitting processes it serves, and its efficiency in reducing emissions of substances on the Air Toxics "Hot Spots" list. The Inventory Guidelines require that this information be included in the Inventory Reports, along with the emission data for each emitting process. If the control equipment did not operate full-time, the reported overall control efficiency must be adjusted to account for downtime of control equipment. Any entrainment of toxic substances to the atmosphere from control equipment should be accounted for; this includes fugitive releases during maintenance and cleaning of control devices (e.g., baghouses and cyclones).

### *2.2.2 Landfill Emissions*

Emission estimates for landfill sites should be based on testing required under Health and Safety Code Section 41805.5 (AB 3374, Calderon) and any supplemental AB 2588 source tests performed to characterize air toxics emissions from landfill surfaces or through off-site migration. The District should be consulted to determine the specific Calderon data to be used in the risk assessment. The Air Toxics "Hot Spots" Program risk assessment for landfills should also include emissions of listed substances for all applicable power generation and maintenance equipment at the landfill site. Processes that need to be addressed include stationary IC engines, flares, evaporation ponds, composting operations, boilers, and gasoline dispensing systems.

### *2.3 Source Characterization*

The facility's emissions need to be characterized according to the source type and quantity in order to select an appropriate air dispersion model.

#### *2.3.1 Classification According to Source Type*

Air dispersion models can be classified according to the type of source that they are designed to simulate, including: point, line, area and volume sources. Several models have the capability to simulate more than one type of source.

##### *2.3.1.1 Point Sources*

Point sources are probably the most common type of source and most air dispersion models have the capability to simulate them. Typical examples of point sources include: isolated vents and stacks.

##### *2.3.1.2 Line Sources*

In practical terms, line sources are a special case of either an area or a volume source, consequently, they are normally modeled using either an area or volume source model as described below. Examples of line sources include: conveyor belts and rail lines.

##### *2.3.1.3 Area Sources*

Emissions that are to be modeled as area sources include fugitive sources characterized by non-buoyant emissions containing negligible vertical extent of release (e.g., no plume rise or distributed over a fixed level).

Fugitive particulate ($PM_{2.5}$, $PM_{10}$, TSP) emission sources include areas of disturbed ground (open pits, unpaved roads, parking lots) which may be present during operational phases of a facility's life. Also included are areas of exposed material (e.g., storage piles and slag dumps) and segments of material transport where potential fugitive emissions may occur (uncovered haul trucks or rail cars, emissions from unpaved roads). Fugitive emissions may also occur during stages of material handling where particulate material is exposed to the atmosphere (uncovered conveyors, hoppers, and crushers).

Other fugitive emissions emanating from many points of release at the same elevation may be modeled as area sources. Examples include fugitive emissions from valves, flanges, venting, and other connections that occur at ground level, or at an elevated level or deck if on a building or structure. Sources of fugitive emissions with a significant vertical extent should be modeled as volume sources.

In general, the computer algorithms used to model area sources impose certain restrictions on the proximity of the receptors to the source. Refer to each model's section for specific restrictions.

#### *2.3.1.4 Volume Sources*

Non-point sources with emissions containing an initial vertical extent should be modeled as volume sources. The initial vertical extent may be due to plume rise or a vertical distribution of numerous smaller sources over a given area. Examples of volume sources include buildings with natural fugitive ventilation, building roof monitors, and line sources such as conveyor belts and rail lines.

### *2.3.2 Classification According to Quantity of Sources*

Selection of an air dispersion model also requires the classification of the source in terms of quantity. Some dispersion models are capable of simulating only one source at a time, and are therefore referred to as single-source models (e.g., SCREEN3).

In some cases, for screening purposes, single-source models may be used in situations involving more than one source using one of the following approaches:

- combining all sources into one single "representative" source

  In order to be able to combine all sources into one single source, the individual sources must have similar release parameters. For example, when modeling more than one stack as a single "representative" stack, the stack gas exit velocities and temperatures must be similar. In order to obtain a conservative estimate, the values leading to the higher concentration estimates should typically be used (e.g., the lowest stack gas exit velocity and temperature, the height of the shortest stack and the distance of the receptor to the nearest stack).

- running the model for each individual source and superimposing results

  Superposition of results of single sources of emissions is the actual approach followed by all the Gaussian models capable of simulating more than one source. Simulating sources in this manner may lead to conservative estimates if worst-case meteorological data are used or if the approach is used with a model that automatically selects worst-case meteorological conditions, especially wind direction. The approach will typically be more conservative the farther apart the sources are because each run would use a different worst-case wind direction.

Additional guidance regarding source merging is provided by the U.S. EPA (1995a). It should be noted that depending upon the population distribution, the total burden can actually increase when pollutants are more widely dispersed. If the total burden from the facility or zone of impact (see Section 2.6.1) could increase for the simplifying modeling assumptions described above, the District should be consulted.

## *2.4 Terrain Characterization*

Two types of terrain characterizations are required to select the appropriate model. One classification is made according to land type and another one according to terrain topography.

### *2.4.1 Classification According to Land Type*

Most air dispersion models use different dispersion coefficients (sigmas) depending on the land use over which the pollutants are being transported. The land use type is also used by some models to select appropriate wind profile exponents. Traditionally, the land type has been categorized into two broad divisions for the purposes of dispersion modeling: urban and rural. Accepted procedures for determining the appropriate category are those suggested by Irwin (1978): one based on land use classification and the other based on population.

The land use procedure is generally considered more definitive. Population density should be used with caution and should not be applied to highly industrialized areas where the population density may be low. For example, in low population density areas a rural classification would be indicated, but if the area is sufficiently industrialized the classification should already be "urban" and urban dispersion parameters should be used.

If the facility is located in an area where land use or terrain changes abruptly, e.g., on the coast, the District should be consulted concerning the classification. The District may require a classification that biases estimated concentrations towards overprediction. As an alternative, the District may require that receptors be grouped according to the terrain between source and receptor.

#### *2.4.1.1 Land Use Procedure*

(1) Classify the land use within the total area A, circumscribed by a 3 km radius circle centered at the source using the meteorological land use typing scheme proposed by Auer (1978) and shown in Table 2.1.

(2) If land use types I1, I2, C1, R2 and R3 account for 50 percent or more of the total area *A* described in (1), use urban dispersion coefficients. Otherwise, use appropriate rural dispersion coefficients.

#### *2.4.1.2 Population Density Procedure*

(1) Compute the average population density (*p*) per square kilometer with *A* as defined in the Land Use procedure described above. (Population estimates are also required to determine the exposed population; for more information see Section 2.6.3.)

(2) If *p* is greater than 750 people/km$^2$ use urban dispersion coefficients, otherwise, use appropriate rural dispersion coefficients.

**Table 2.1 Identification and classification of land use types (Auer, 1978).**

| Type | Use and Structures | Vegetation |
|---|---|---|
| I1 | *Heavy Industrial*<br>Major chemical, steel and fabrication industries; generally 3-5 story buildings, flat roofs | Grass and tree growth extremely rare; <5% vegetation |
| I2 | *Light-moderate industrial*<br>Rail yards, truck depots, warehouses, industrial parks, minor fabrications; generally 1-3 story buildings, flat roofs | Very limited grass, trees almost totally absent; <5% vegetation |
| C1 | *Commercial*<br>Office and apartment buildings, hotels; >10 story heights, flat roofs | Limited grass and trees; <15% vegetation |
| R1 | *Common residential*<br>Single family dwelling with normal easements; generally one story, pitched roof structures; frequent driveways | Abundant grass lawns and light-moderately wooded; >70% vegetation |
| R2 | *Compact residential*<br>Single, some multiple, family dwelling with close spacing; generally <2 story, pitched roof structures; garages (via alley), no driveways | Limited lawn sizes and shade trees; <30% vegetation |
| R3 | *Compact residential*<br>Old multi-family dwellings with close (<2 m) lateral separation; generally 2 story, flat roof structures; garages (via alley) and ashpits, no driveways | Limited lawn sizes, old established shade trees; <35% vegetation |
| R4 | *Estate residential*<br>Expansive family dwelling on multi-acre tracts | Abundant grass lawns and lightly wooded; >80% vegetation |
| A1 | *Metropolitan natural*<br>Major municipal, state, or federal parks, golf courses, cemeteries, campuses; occasional single story structures | Nearly total grass and lightly wooded; >95% vegetation |
| A2 | *Agricultural rural* | Local crops (e.g., corn, soybean); >95% vegetation |
| A3 | *Undeveloped*<br>Uncultivated; wasteland | Mostly wild grasses and weeds, lightly wooded; >90% vegetation |
| A4 | *Undeveloped rural* | Heavily wooded; >95% vegetation |
| A5 | *Water surfaces*<br>Rivers, lakes | |

### *2.4.2 Classification According to Terrain Topography*

Surface conditions and topographic features generate turbulence, modify vertical and horizontal winds, and change the temperature and humidity distributions in the boundary layer of the atmosphere. These in turn affect pollutant dispersion and various models differ in their need to take these factors into account.

The classification according to terrain topography should ultimately be based on the topography at the receptor location with careful consideration of the topographical features between the receptor and the source. Topography can be classified as follows:

#### *2.4.2.1 Simple Terrain (alsoReferred to as "Rolling Terrain")*

Simple terrain is all terrain located below stack height including gradually rising terrain (i.e., rolling terrain). Note that *Flat Terrain* also falls in the category of simple terrain.

#### *2.4.2.2 Intermediate Terrain*

Intermediate terrain is terrain located above stack height and below plume height. The recommended procedure to estimate concentrations for receptors in intermediate terrain is to perform an hour-by-hour comparison of concentrations predicted by simple and complex terrain models. The higher of the two concentrations should be reported and used in the risk assessment.

#### *2.4.2.3 Complex Terrain*

Complex terrain is terrain located above plume height. Complex terrain models are necessarily more complicated than simple terrain models. There may be situations in which a facility is "overall" located in complex terrain but in which the nearby surroundings of the facility can be considered simple terrain. In such cases, receptors close to the facility in this area of simple terrain will "dominate" the risk analysis and there may be no need to use a complex terrain model.

## *2.5 Level of Detail: Screening VS. Refined Analysis*

Air dispersion models can be classified according to the level of detail which is used in the assessment of the concentration estimates as "screening" or "refined". Refined air dispersion models use more robust algorithms capable of using representative meteorological data to predict more representative and usually less conservative estimates. Refined air dispersion models are, however, more resource intensive than their screening counterparts. It is advisable to first use a screening model to obtain conservative concentration estimates and calculate health risks. If the health risks are estimated to be above the threshold of concern, then use of a refined model to calculate more representative concentration and health risk estimates would be warranted. There are situations when screening models represent the only viable alternative (e.g., when representative meteorological data are not available).

It is acceptable to use a refined air dispersion model in a “screening” mode for this program’s health risk assessments. In this case, a refined air dispersion model is used:

- with worst-case meteorology instead of representative meteorology
- with a conservative averaging period conversion factor to calculate longer term concentration estimates

Note that use of worst case meteorology in a refined model is not the normal practice in New Source Review or Ambient Air Quality Standard evaluation modeling.

### *2.6 Population Exposure*

The level of detail required for the analysis (e.g., screening or refined), and the procedures to be used in determining geographic resolution and exposed population require case-by-case analysis and professional judgment. The District should be consulted before beginning the population exposure estimates and as results are generated, further consultation may be necessary. Some suggested approaches and methods for handling the breakdown of population and performance of a screening or detailed risk analysis are provided in this section.

#### *2.6.1 Zone of Impact*

As part of the estimation of the population exposure for the cancer risk analysis, it is necessary to determine the geographic area affected by the facility’s emissions. An initial approach to define a “zone of impact” surrounding the source is to generate an isopleth in which the total excess lifetime cancer risk from inhalation exposure to all emitted carcinogens is greater than $10^{-6}$ (one in 1,000,000). For noncarcinogens, a second and third isopleth (to represent both chronic and acute Health Hazard Indices) on a separate map would be created to define the zone of impact for the hazard index from both inhalation and noninhalation pathways greater than or equal to 1.0. For clarity these isopleths may need to be presented on separate maps.

The initial “zone of impact” can be determined as follows:

- Use a screening dispersion model (e.g., SCREEN3) to obtain concentration estimates for each emitted pollutant at varying receptor distances from the source. Several screening models feature the generation of an automatic array of receptors which is particularly useful for determining the zone of impact. In order for the model to generate the array of receptors the user needs to provide some information normally consisting of starting distance, increment and number of intervals.

- Calculate total cancer risk and hazard index (HI) for each receptor location by using the methods provided in the risk characterization sections of this document.

- Find the distance where the total inhalation cancer risk is equal to $10^{-6}$; this may require redefining the receptor array in order to have two receptor locations that bound a total cancer risk of $10^{-6}$. This exercise should be repeated for the noncancer health impacts.

Some Districts may prefer to use a cancer risk of $10^{-7}$ as the zone of impact. Therefore, the District should be consulted before modeling efforts are initiated. If the zone of impact is greater than 25 km from the facility at any point, the District should be consulted. The District may specify limits on the area of the zone of impact. Ideally, these preferences would be presented in the modeling protocol (see Section 2.14).

Note that when depicting the risk assessment results, risk isopleths must present the total cancer and noncancer risk from both inhalation and noninhalation pathways. The zone of impact should be clearly shown on a map with geographic markers of adequate resolution (see Section 2.6.3.1).

### *2.6.2 Population Estimates for Screening Risk Assessments*

A screening risk assessment should include an estimate of the maximum exposed population. For screening risk assessments, a detailed description of the exposed population is not required. The impact area to be considered should be selected to be health protective (i.e., will not underestimate the number of exposed individuals). A health-protective assumption is to assume that all individuals within a large radius of the facility are exposed to the maximum concentration. If a facility must also comply with the RCRA/CERCLA risk assessment requirements, health effects to on-site workers may also need to be addressed. The DTSC's Remedial Project Manager should be consulted on this issue. The District should be consulted to determine the population estimate that should be used for screening purposes.

### *2.6.3 Population Estimates for Refined Risk Assessments*

The refined risk assessment requires a detailed analysis of the population that is exposed to emissions from the facility. A detailed population exposure analysis provides estimates of the number of individuals in residences and off-site workplaces, as well as at sensitive receptor sites such as schools, daycare centers and hospitals. The District may require that locations with high densities of sensitive individuals be identified (e.g., schools, daycare centers, hospitals). The overall exposed residential and worker populations should be apportioned into smaller geographic subareas. The information needed for each subarea is:

(1) the number of exposed persons, and
(2) the receptor location at which the calculated ambient air concentration is assumed to be representative of the exposure to the entire population in the subarea.

A multi-tiered approach is suggested for the population analysis. First, census tracts which the facility could significantly impact should be identified (see Section 2.6.3.1). A census tract should be divided into smaller subareas if it is close to the facility where ambient concentrations vary widely. The District may determine that census tracts provide sufficient resolution near the facility to adequately characterize population exposure.

Further downwind where ambient concentrations are less variable, the census tract level may be acceptable to the District. The District may determine that the aggregation of census tracts (e.g., the census tracts making up a city are combined) is appropriate for receptors which are considerable distances from the facility. If a facility must also comply with the RCRA/CERCLA risk assessment requirements, health effects to on-site workers may also need to be addressed. The DTSC's Remedial Project Manager should be consulted on this issue. In addition, the district should be consulted about special cases for which evaluation of on-site receptors is appropriate, such as facilities frequented by the public or where people may reside (e.g. military facilities).

#### *2.6.3.1 Census Tracts*

For a refined risk assessment, the boundaries of census tracts can be used to define the geographic area to be included in the population exposure analysis. Maps showing census tract boundaries and numbers can be obtained from "The Thomas Guide® - Census Tract Edition". Statistics for each census tract can be obtained from the U.S. Census Bureau. Numerous additional publicly accessible or commercially available sources of census data can be found on the World Wide Web. A specific example of a census tract is given in Appendix J.

The two basic steps in defining the area under analysis are:

(1) Identify the "zone of impact" (as defined previously in Section 2.6.1) on a map detailed enough to provide for resolution of the population to the subcensus tract level. (The U.S. Geological Survey (USGS) 7.5-minute series maps provide sufficient detail.) This is necessary to clearly identify the zone of impact, location of the facility, and sensitive receptors within the zone of impact. If significant development has occurred since the USGS survey, this should be indicated. A specific example of a 7.5-minute series map is given in Appendix J.

(2) Identify all census tracts within the zone of impact using a U.S. Bureau of Census or equivalent map (e.g., Thomas Brothers). If only a portion of the census tract lies within the zone of impact, the population used in the burden calculation should include the proportion of the population in that isopleth zone. The census tract boundaries should be transferred to a map, such as a USGS map (referred to hereafter as the "base map".)

An alternative approach for estimating population exposure in heavily populated urban areas is to apportion census tracts to a Cartesian grid cell coordinate system. This method allows a Cartesian coordinate receptor concentration field to be merged with the population grid cells. This process may be computerized and minimizes manual mapping of centroids and census tracts.

The District may determine that aggregation of census tracts (e.g., which census tracts making up a city can be combined) is appropriate for receptors that are located at considerable distances from the facility. If the District permits such an approach, it is suggested that the census tract used to represent the aggregate be selected in a manner to ensure that the approach is health protective. For example, the census tract included in the aggregate that is nearest (downwind) to the facility should be used to represent the aggregate.

#### *2.6.3.2 Subcensus Tract*

Within each census tract are smaller population units. These units [urban block groups (BG) and rural enumeration districts (ED)] contain about 1,100 persons. BGs are further broken down into statistical units called blocks. Blocks are generally bounded by four streets and contain an average of 70 to 100 persons. However, the populations presented above are average figures and population units may vary significantly. In some cases, the EDs are very large and identical to a census tract.

The area requiring detailed (subcensus tract) resolution of the exposed residential and worker population will need to be determined on a case-by-case basis through consultation with the District. The District may determine that census tracts provide sufficient resolution near the facility to adequately characterize population exposure.

It is necessary to limit the size of the detailed analysis area because inclusion of all subcensus tracts would greatly increase the resource requirements of the analysis. For example, an urban area of 100,000 persons would involve approximately 25 census tracts, approximately 100 to 150 block groups, and approximately 1,000 to 1,400 blocks. Furthermore, a high degree of resolution at large distances from a source would not significantly affect the analysis because the concentration gradient at these distances is generally small. Thus, the detailed analysis of census tracts within several kilometers of a facility should be sufficient. The District should be consulted to determine the area that requires detailed analysis.

The District should also be consulted to determine the degree of resolution required. In some cases, resolution of residential populations to the BG/ED level may be sufficient. However, resolution to the block level may also be required for those BG/EDs closest to the facility or those having maximum concentration impacts. The identified employment subareas should be resolved to a similar degree of resolution as the residential population. For each subarea analyzed, the number of residents and/or workers exposed should be estimated.

Employment population data can be obtained at the census tract level from the U.S. Census Bureau or from local planning agencies. This degree of resolution will generally not be sufficient for most risk assessments. For the area requiring detailed analysis, zoning maps, general plans, and other planning documents should be consulted to identify subareas with worker populations.

The boundaries of each residential and employment population area should be transferred to the base map.

### *2.6.4 Sensitive Receptor Locations*

Individuals who may be more sensitive to toxic exposures than the general population are distributed throughout the total population. Sensitive populations may include young children and chronically ill individuals. The District may require that locations with high densities of sensitive individuals be identified (e.g., schools, daycare centers, hospitals). The risk assessment should state what the District requirements were regarding identification of sensitive receptor locations.

Although sensitive individuals are protected by general assumptions made in the cancer risk assessment, their identification may be useful to assure the public that such individuals are being considered in the analysis. For noncancer effects, the identification of such individuals may be crucial in evaluating the potential impact of the toxic effect.

## *2.7 Receptor Siting*

### *2.7.1 Receptor Points*

The modeling analysis should contain a network of receptor points with sufficient detail (in number and density) to permit the estimation of the maximum concentrations. Locations that must be identified include the maximum estimated off-site risk or point of maximum impact (PMI), the maximum exposed individual at an existing residential receptor (MEIR) and the maximum exposed individual at an existing occupational receptor (worker) (MEIW). All of these locations (i.e., PMI, MEIR, and MEIW) must be identified for carcinogenic and noncarcinogenic effects. It is possible that the estimated PMI, MEIR and MEIW risk for carcinogenic, chronic noncarcinogenic, and acute noncarcinogenic health effects occur at different locations. The results from a screening model (if available) can be used to identify the area(s) where the maximum concentrations are likely to occur. Receptor points should also be located at the population centroids (see Section 2.7.2) and sensitive receptor locations (see Section 2.6.4). The exact configuration of the receptor array used in an analysis will depend on the topography, population distribution patterns, and other site-specific factors. All receptor locations should be identified in the risk assessment using UTM (Universal Transverse Mercator) coordinates and receptor number. The receptor numbers in the summary tables should match receptor numbers in the computer output. In addition to UTM coordinates, the street address(es), where possible and as required by the local district, should be provided for the PMI, MEIR and MEIW for carcinogenic and noncarcinogenic health effects.

To evaluate localized impacts, receptor height should be taken into account at the point of maximum impact on a case-by-case basis. For example, receptor heights may have to be included to account for receptors significantly above ground level. Flagpole receptors to represent the breathing zone, or direct inhalation, of a person may need to be considered when the source receptor distance is less than a few hundred meters. Consideration must also be given to the multipathway analysis which requires the deposition at ground level. A health protective approach is to select a receptor height from 0 meters to 1.8 meters that will result in the highest predicted downwind concentration. Final approval should be with District.

### *2.7.2 Centroid Locations*

For each subarea analyzed, a centroid location (the location at which a calculated ambient concentration is assumed to represent the entire subarea) should be determined. When population is uniformly distributed within a population unit, a geographic centroid based on the shape of the population unit can be used. Where population is not uniformly distributed, a population-weighted centroid is needed. Another alternative could be to use the concentration at the point of maximum impact within that census tract as the concentration to which the entire population of that census tract is exposed.

The centroids represent locations that should be included as receptor points in the dispersion modeling analysis. Annual average concentrations should be calculated at each centroid using the modeling procedures presented in this chapter.

For census tracts and BG/EDs, judgments can be made using census tracts maps and street maps to determine the centroid location. At the block level, a geographic centroid is sufficient.

## *2.8 Meteorological Data*

Refined air dispersion models require hourly meteorological data. The first step in obtaining meteorological data should be to check with the District for data availability. Other sources of data include the National Weather Service (NWS), National Climatic Data Center (NCDC), Asheville, North Carolina, military stations and private networks. Meteorological data for a subset of NWS stations are available from the U.S. EPA Support Center for Regulatory Air Models (SCRAM). The SCRAM can be accessed at www.epa.gov/scram001/main.htm. All meteorological data sources should be approved by the District. Data not obtained directly from the District should be checked for quality, representativeness and completeness. U.S. EPA provides guidance (U.S. EPA, 1995c) for these data. The risk assessment should indicate if the District required the use of a specified meteorological data set. All memos indicating District approval of meteorological data should be attached in an appendix. If no representative meteorological data are available, screening procedures should be used.

The analyst should acquire enough meteorological data to ensure that the worst-case meteorological conditions are represented in the model results. The period of record recommended for use in the air dispersion model is five years. If it is desired to use a single year to represent long-term averages (i.e., chronic exposure), then the worst-case year should be used. The worst-case year should be the year that yields the greatest maximum chronic off-site risk. If the only adverse health effects associated with all emitted pollutants from a given facility are acute, the worst-case year should be the year that yields the greatest maximum acute off-site risk. However, the District may determine that one year of representative meteorological data is sufficient to adequately characterize the facility’s impact.

Otherwise, to determine annual average concentrations for analysis of chronic health effects, the data can be averaged if a minimum of three years of meteorological data are available. For calculation of the one-hour maximum concentrations needed to evaluate acute effects, the worst-case year should be used in conjunction with the maximum hourly emission rate. For example, the annual average concentration and one-hour maximum concentration at a single receptor for five years of meteorological data are calculated below:

| Year | Annual Average ($\mu g/m^3$) | Maximum One-Hour ($\mu g/m^3$) |
|---|---|---|
| 1 | 7 | 100 |
| 2 | 5 | 80 |
| 3 | 9 | 90 |
| 4 | 8 | 110 |
| 5 | 6 | 90 |
| 5-year average | 7 | |

In the above example, the long-term average concentration over five years is 7.0 $\mu g/m^3$. Therefore, 7 $\mu g/m^3$ should be used to evaluate carcinogenic and chronic effects (i.e., annual average concentration). The one-hour maximum concentration is the highest one-hour concentration in the five-year period. Therefore, 110 $\mu g/m^3$ is the peak one-hour concentration that should be used to evaluate acute effects.

During the transitional period from night to day (i.e., the first one to three hours of daylight) the meteorological processor may interpolate some very low mixing heights. This is a period of time in which the mixing height may be growing rapidly. When predicted concentrations are high and the mixing height is very low for the corresponding averaging period, the modeling results deserve additional consideration. For receptors in the near field, it is within the model formulation to accept a very low mixing height for short durations. However, it would be unlikely that the very low mixing height would persist long enough for the pollutants to travel into the far field. In the event that the analyst identifies any of these time periods, they should be discussed with the District on a case-by-case basis.

The following sections, taken mostly from the document “On-Site Meteorological Program Guidance for Regulatory Modeling Applications” (U.S. EPA, 1995e), provide general information on data formats and representativeness. Some Districts may have slightly different recommendations from those given here.

### *2.8.1 Meteorological Data Formats*

Most short-term dispersion models require input of hourly meteorological data in a format which depends on the model. U.S. EPA provides software for processing meteorological data for use in U.S. EPA recommended dispersion models. U.S. EPA recommended meteorological processors include the Meteorological Processor for Regulatory Models (MPRM) and PCRAMMET. Use of these processors will ensure that the meteorological data used in an U.S. EPA recommended dispersion model will be processed in a manner consistent with the requirements of the model.

The input format for the U.S. EPA long-term models should be of the stability wind rose (STAR) variety generated for the National Weather Service (NWS) stations by the National

Climatic Data Center. U.S. EPA recommended software for processing STAR data includes the PCSTAR program and MPRM. Individual model user's guides should be referred to for additional details on input data formats.

Meteorological data for a subset of NWS stations are available on the World Wide Web at the U.S. EPA SCRAM address, http://www.epa.gov/scram001.

### *2.8.2 Treatment of Calms*

Calms are normally considered to be wind speeds below the starting threshold of the anemometer or vane (whichever is greater). U.S. EPA's policy is to disregard calms until such time as an appropriate analytical approach is available. The recommended U.S. EPA models contain a routine that eliminates the effect of the calms by nullifying concentrations during calm hours and recalculating short-term and annual average concentrations. Certain models lacking this built-in feature can have their output processed by U.S. EPA's CALMPRO program (U.S. EPA, 1984a) to achieve the same effect. Because the adjustments to the concentrations for calms are made by either the models or the postprocessor, actual measured on-site wind speeds should always be input to the preprocessor. These actual wind speeds should then be adjusted as appropriate under the current U.S. EPA guidance by the preprocessor.

Following the U.S. EPA methodology, measured on-site wind speeds of less than l.0 m/s, but above the instrument threshold, should be set equal to l.0 m/s by the preprocessor when used as input to Gaussian models. Calms are identified in the preprocessed data file by a wind speed of 1.0 m/s and a wind direction equal to the previous hour. Some air districts provide pre-processed meteorological data for use in their district that treats calms differently. Local air districts should be consulted for available meteorological data.

### *2.8.3 Treatment of Missing Data*

Missing data refer to those hours for which no meteorological data are available from the primary on-site source for the variable in question. In order for the regulatory models to function properly, there must be a data value in each input field. When missing values arise, they should be handled in one of the following ways listed below, in the following order of preference:

(1) If there are other on-site data, such as measurements at another height, they may be used when the primary data are missing. If the height differences are significant, corrections based on established vertical profiles should be made. Site-specific vertical profiles based on historical on-site data may also be appropriate to use if their determination is approved by the reviewing authority. If there is question as to the representativeness of the other on-site data, they should not be used.

(2) If there are only one or two missing hours, then linear interpolation of missing data may be acceptable, however, caution should be used when the missing hour(s) occur(s) during day/night transition periods.

(3) If representative off-site data exist, they may be used. In many cases this approach may be acceptable for cloud cover, ceiling height, mixing height, and temperature. This approach will rarely be acceptable for wind speed and direction. The representativeness of off-site data should be discussed and agreed upon in advance with the reviewing authority.

(4) Failing any of the above, the data field should be coded as a field of nines. This value will act as a missing flag in any further use of the data set.

At the present time, the short-term regulatory models contain no mechanism for handling missing data in the sequential input file. Therefore, in order to run these models a complete data set, including substitutions, is required. Substitutions for missing data should only be made in order to complete the data set for modeling applications, and should not be used to attain the "regulatory completeness" requirement of 90%. That is, the meteorological data base must be 90% complete on a monthly basis (before substitution) in order to be acceptable for use in air dispersion modeling.

### *2.8.4 Representativeness of Meteorological Data*

The atmospheric dispersion characteristics at an emission source needs to be evaluated to determine if the collected meteorological data can be used to adequately represent the emission source dispersion.

Such determinations are required when the available meteorological data are acquired at a location other than that of the proposed source. In some instances, even though meteorological data are acquired at the location of the pollutant source, they still may not correctly characterize the important atmospheric dispersion conditions.

Considerations of representativeness are always made with the meteorological data sets used in atmospheric dispersion modeling whether the data base is "on-site" or "off-site." These considerations call for the judgment of a meteorologist or an equivalent professional with expertise in atmospheric dispersion modeling. If in doubt, the District should be consulted.

#### *2.8.4.1 Spatial Dependence*

The location where the meteorological data are acquired should be compared to the source location for similarity of terrain features. For example, in complex terrain, the following considerations should be addressed in consultation with the District:

- Aspect ratio of terrain, i.e., ratio of:
  - Height of valley walls to width of valley;
  - Height of ridge to length of ridge; and
  - Height of isolated hill to width of hill at base.
- Slope of terrain
- Ratio of terrain height to stack/plume height.
- Distance of source from terrain (i.e., how close to valley wall, ridge, isolated hill).

- Correlation of terrain feature to prevailing meteorological conditions.

Likewise, if the source is located on a plateau or plain, the source of meteorological data used should be from a similar plateau or plain.

Judgments of representativeness should be made only when sites are climatologically similar. Sites in nearby but different air sheds often exhibit different weather patterns. For instance, meteorological data acquired along a shoreline are not normally representative of inland sites and vice versa.

Meteorological data collected need to be examined to determine if drainage, transition, and synoptic flow patterns are characteristics of the source, especially those critical to the regulatory application. Consideration of orientation, temperature, and ground cover should be included in the review.

An important aspect of space dependence is height above the ground. Where practical, meteorological data should be acquired at the release height, as well as above or below, depending on the buoyancy of the source's emissions.

#### *2.8.4.2 Temporal Dependence*

To be representative, meteorological data must be of sufficient duration to define the range of sequential atmospheric conditions anticipated at a site. As a minimum, one full year of on-site meteorological data is necessary to prescribe this time series. Multiple years of data are used to describe variations in annual and short-term impacts. In general, the climatic period of five years is adequate to represent these yearly variations.

#### *2.8.4.3 Further Considerations*

It may be necessary to recognize the non-homogeneity of meteorological variables in the air mass in which pollutants disperse. This non-homogeneity may be essential in correctly describing the dispersion phenomena. Therefore, measurements of meteorological variables at multiple locations and heights may be required to correctly represent these meteorological fields. Such measurements are generally required in complex terrain or near large land-water body interfaces.

It is important to recognize that, although certain meteorological variables may be considered unrepresentative of another site (for instance, wind direction or wind speed), other variables may be representative (such as temperature, dew point, cloud cover). Exclusion of one variable does not necessarily exclude all. For instance, one can argue that weather observations made at different locations are likely to be similar if the observers at each location are within sight of one another - a stronger argument can be made for some types of observations (e.g., cloud cover) than others. Although by no means a sufficient condition, the fact that two observers can “see” one another supports a conclusion that they would observe similar weather conditions.

Other factors affecting representativeness include change in surface roughness, topography and atmospheric stability. Currently there are no established analytical or statistical techniques to determine representativeness of meteorological data. The establishment and maintenance of an on-site data collection program generally fulfills the requirement for "representative" data. If in doubt, the District should be consulted.

### *2.8.5 Alternative Meteorological Data Sources*

It is necessary, in the consideration of most air pollution problems, to obtain data on site-specific atmospheric dispersion. Frequently, an on-site measurement program must be initiated. As discussed in Section 2.8.3, representative off-site data may be used to substitute for missing periods of on-site data. There are also situations where current or past meteorological records from a National Weather Service station may suffice. These considerations call for the judgment of a meteorologist or an equivalent professional with expertise in atmospheric dispersion modeling. More information on Weather Stations including: National Weather Service (NWS), military observations, supplementary airways reporting stations, upper air and private networks, is provided in "On-Site Meteorological Program Guidance for Regulatory Modeling Applications" (U.S. EPA, 1995e).

#### *2.8.5.1 Recommendations*

On-site meteorological data should be processed to provide input data in a format consistent with the particular models being used. The input format for U.S. EPA short-term regulatory models is defined in U.S. EPA's MPRM. The format for U.S. EPA long-term models is the STAR format utilized by the National Climatic Data Center. Both processors are available on the SCRAM web site. The actual wind speeds should be coded on the original input data set. Wind speeds less than 1.0 m/s but above the instrument threshold should be set equal to 1.0 m/s by the preprocessor when used as input to Gaussian models. Wind speeds below the instrument threshold of the cup or vane, whichever is greater, should be considered calm, and are identified in the preprocessed data file by a wind speed of 1.0 m/s and a wind direction equal to the previous hour.

If data are missing from the primary source, they should be handled as follows, in order of preference: (l) substitution of other representative on-site data; (2) linear interpolation of one or two missing hours; (3) substitution of representative off-site data; or (4) coding as a field of nines, according to the discussions in Section 2.8.3. However, in order to run existing short-term regulatory models, a complete data set, including substitutions, is required.

If the data processing recommendations in this section cannot be achieved, then alternative approaches should be developed in conjunction with the District.

### *2.8.6 Quality Assurance and Control*

The purpose of quality assurance and maintenance is the generation of a representative amount (90% of hourly values for a year on a monthly basis) of valid data. For more information on data validation consult reference U.S. EPA (1995e). Maintenance may be considered the physical activity necessary to keep the measurement system operating as it should. Quality assurance is the management effort to achieve the goal of valid data through plans of action and documentation of compliance with the plans.

Quality assurance (QA) will be most effective when following a QA Plan which has been signed-off by appropriate project or organizational authority. The QA Plan should contain the following information (paraphrased and particularized to meteorology from Lockhart):

1. Project description - how meteorology data are to be used
2. Project organization - how data validity is supported
3. QA objective - how QA will document validity claims
4. Calibration method and frequency - for data
5. Data flow - from samples to archived valid values
6. Validation and reporting methods - for data
7. Audits - performance and system
8. Preventive maintenance
9. Procedures to implement QA objectives - details
10. Management support - corrective action and reports

It is important for the person providing the quality assurance (QA) function to be independent of the organization responsible for the collection of the data and the maintenance of the measurement systems. Ideally, the QA auditor works for a separate company.

## *2.9 Model Selection*

There are several air dispersion models that can be used to estimate pollutant concentrations and new ones are likely to be developed. U.S. EPA is in the process of adding three new models to the preferred list of models: ISC-PRIME, AERMOD, and CalPuff. The latest version of the U.S. EPA recommended models can be found at the SCRAM Bulletin board located at http://www.epa.gov/scram001. However, any model, whether a U.S. EPA guideline model or otherwise, must be approved for use by the local air district. Recommended models and guidelines for using alternative models are presented in this section. New models placed on U.S. EPA's preferred list of models (i.e., ISC-PRIME, AERMOD, and CalPuff) can be considered at that time. All air dispersion models used to estimate pollutant concentrations for risk assessment analyses must be in the public domain. Classification according to terrain, source type and level of analysis is necessary before selecting a model (see Section 2.4). The selection of averaging times in the modeling analysis is based on the health effects of concern. Annual average concentrations are required for an analysis of carcinogenic or other chronic effects. One-hour maximum concentrations are generally required for analysis of acute effects.

### *2.9.1 Recommended Models*

Recommended air dispersion models to estimate concentrations for risk assessment analyses are shown in Table 2.2. Currently, SCREEN3 and ISCST3 are the two models used for most risk assessments. This could change when the U.S. EPA places ISC-PRIME, AERMOD, and CalPuff on the preferred list. Some of the names of the air dispersion models reflect the version number at the time of the writing of this document. The most current version of the models should be used for the risk assessment analysis. More than one model may be necessary in some situations, for example, when modeling scenarios have receptors in simple and complex terrain. Some facilities may also require models capable of handling special circumstances such as building downwash, dispersion near coastal areas, etc. For more information on modeling special cases see Sections 2.12 and 2.13.

Most air dispersion models contain provisions that allow the user to select among alternative algorithms to calculate pollutant concentrations. Only some of these algorithms are approved for regulatory application such as the preparation of health risk assessments. The sections in this guideline that provide a description of each recommended model contain information on the specific switches and/or algorithms that must be selected for regulatory application.

To further facilitate the model selection, the District should be consulted for additional recommendations on the appropriate model(s) or a protocol submitted for District review and approval (see Section 2.14.1).

**TABLE 2.2 Recommended Air Dispersion Models**

| | AVERAGING PERIOD | TERRAIN TYPE | SINGLE SOURCE | | MULTIPLE SOURCE | |
|---|---|---|---|---|---|---|
| | | | RURAL | URBAN | RURAL | URBAN |
| REFINED MODELS | SHORT TERM (1-24 hour avg) | SIMPLE | ISCST3 | RAM<br>ISCST3 | ISCST3 | RAM<br>ISCST3 |
| | | COMPLEX | CTDMPLUS | CTDMPLUS | CTDMPLUS | CTDMPLUS |
| | LONG TERM (Monthly-Annual) | SIMPLE | ISCST3<br>ISCLT3 | RAM<br>ISCST3,<br>ISCLT3 | ISCST3<br>ISCLT3 | CDM20 / RAM<br>ISCST3<br>ISCLT3 |
| | | COMPLEX | CTDMPLUS | CTDMPLUS | CTDMPLUS | CTDMPLUS |
| SCREENING MODELS | SHORT TERM (1-24 hour avg) | SIMPLE | SCREEN3 | SCREEN3 | SCREEN3 | SCREEN3 |
| | | COMPLEX | ISCST3<br>RTDM, CTSCREEN<br>VALLEY SCRN | SHORTZ<br>CTSCREEN<br>VALLEY SCRN | ISCST3<br>CTSCREEN*<br>VALLEY SCRN | SHORTZ<br>CTSCREEN*<br>VALLEY SCRN |
| | LONG TERM (Monthly-Annual) | SIMPLE | SCREEN3 | SCREEN3 | SCREEN3 | SCREEN3 |
| | | COMPLEX | ISCST3<br>RTDM | LONGZ | ISCST3 | LONGZ |
| | Other models (e.g., ISC-PRIME, AERMOD, CalPuff) may be added to this list at a future date. | | | | | |

### *2.9.2 Alternative Models*

Alternative models are acceptable if applicability is demonstrated or if they produce results identical or superior to those obtained using one of the preferred models shown in Table 2.2. For more information on the applicability of alternative models refer to the following documents:

- U.S. EPA (1986). "Guideline on Air Quality Models (Revised)" Section 3.2.2
- U.S. EPA (1992). "Protocol for Determining the Best Performing Model"
- U.S. EPA (1985a). "Interim Procedures for Evaluating Air Quality Models – Experience with Implementation"
- U.S. EPA (1984b). "Interim Procedures for Evaluating Air Quality Models (Revised)"

## *2.10 Screening Air Dispersion Models*

A screening model may be used to provide a maximum concentration that is biased toward overestimation of public exposure. Use of screening models in place of refined modeling procedures is optional unless the District specifically requires the use of a refined model. Screening models are normally used when no representative meteorological data are available and may be used as a preliminary estimate to determine if a more detailed assessment is warranted. Specific information about the screening models presented in Table 2.2 is provided in the following subsections. For more information regarding general aspects of model selection see Section 2.9.

Some screening models provide only 1-hour average concentration estimates. Maximum 1-hour concentration averages can be converted to other averaging periods in consultation and with approval of the responsible air district. Because of variations in local meteorology, the exact factor selected may vary from one district to another. Table 2.3 provides guidance on the range and typical values applied. The conversion factors are designed to bias predicted longer term averaging periods towards overestimation.

**Table 2.3. Recommended Factors to Convert Maximum 1-hour Avg. Concentrations to Other Averaging Periods (U.S. EPA, 1995a; ARB, 1994).**

| Averaging Time | Range | Typical Recommended |
|---|---|---|
| 3 hours | 0.8 - 1.0 | 0.9 |
| 8 hours | 0.5 - 0.9 | 0.7 |
| 24 hours | 0.2 - 0.6 | 0.4 |
| 30 days | 0.2 - 0.3 | 0.3 |
| Annual | 0.06 - 0.1 | 0.08 |

### *2.10.1 SCREEN3*

The SCREEN3 model is among the most widely used model primarily because it has been periodically updated to reflect changes in air dispersion modeling practices and theories. The SCREEN3 model represents a good balance between ease of use and the capabilities and flexibility of the algorithms. In addition, the calculations performed by the model are very well documented (U.S. EPA, 1995a). The SCREEN3 User's Guide (U.S. EPA, 1995d) also presents technical information and provides references to other support documents.

The most important difference between the SCREEN3 model and refined models such as ISCST3 is the meteorological data used to estimate pollutant concentrations. The SCREEN3 model can assume worst-case meteorology, which greatly simplifies the resources and time normally associated with obtaining meteorological data. Consequently, more conservative (higher concentration) estimates are normally obtained. Alternatively, a single stability class and wind speed may also be entered.

*Number of Sources and Type*

SCREEN3 was designed to simulate only a single source at a time. However, more than one source may be modeled by consolidating the emissions into one emission point or by individually running each point source and adding the results. SCREEN3 can be used to model point sources, flare releases, and simple area and volume sources. Input parameters required for various source-types are shown in Tables 2.4 (point), 2.5 (flare release), 2.6 (area) and 2.7 (volume).

**Table 2.4. Required Input Parameters to Model a Point Source Using SCREEN3.**

| | |
|---|---|
| Emission Rate (g/s) | |
| Stack Height (m) | |
| Stack Inside Diameter (m) | |
| Stack Gas Exit Velocity (m/s) or Volumetric Flow Rate (ACFM, $m^3$/s) | |
| Stack Gas Temperature (K) | |
| Ambient Temperature (K) | |
| Receptor Height Above Ground (m) | |
| Receptor Distance from the Source (m) | [discrete distance or automated array] |
| Land Type | [urban or rural] |
| Meteorology: none | [option "1" (full meteorology) is normally selected] |
| *In Addition, for building downwash calculations* | |
| Building Height (m) | |
| Minimum Horizontal Dimension (m) | |
| Maximum Horizontal Dimension (m) | |

**Table 2.5. Required Input Parameters to Model a Flare Using SCREEN3.**

| | |
|---|---|
| Emission Rate (g/s) | |
| Flare Stack Height (m) | |
| Total Heat Release (cal/s) | |
| Receptor Height Above Ground (m) | |
| Receptor Distance from the Source (m) | |
| Land Type | [urban or rural] |
| Meteorology: none | [option “1” (full meteorology) is normally selected] |
| *In Addition, for building downwash calculations* | |
| Building Height (m) | |
| Minimum Horizontal Dimension (m) | |
| Maximum Horizontal Dimension (m) | |

**Table 2.6. Required Input Parameters to Model an Area Source Using SCREEN3.**

| | |
|---|---|
| Emission Rate (g/s-$m^2$) | |
| Source Release Height (m) | |
| Length of Larger Side of the Rectangular Area (m) | |
| Length of Smaller Side of the Rectangular Area (m) | |
| Receptor Height Above Ground (m) | |
| Receptor Distance from the Source (m) | |
| Land Type | [urban or rural] |
| Meteorology: none | [option “1” (full meteorology) is normally selected]<br>[wind direction optional] |

**Table 2.7. Required Input Parameters to Model a Volume Source Using SCREEN3.**

| | |
|---|---|
| Emission Rate (g/s) | |
| Source Release Height (m) | |
| Initial Lateral Dimension of Volume (m) | |
| Initial Vertical Dimension of Volume (m) | |
| Receptor Height Above Ground (m) | |
| Receptor Distance from the Source (m) | |
| Land Type | [urban or rural] |
| Meteorology: none | [option "1" (full meteorology) is normally selected] |

*Regulatory Options*

SCREEN3 algorithms contain all regulatory options internally coded including: stack-tip downwash and buoyancy-induced dispersion. These regulatory options are the default settings of the parameters so the user does not need to set any switches during a run.

*Special Cases*

SCREEN3 has the capability to model several special cases by setting switches in the input file or by responding to on-screen questions (if run interactively). The special cases include:

- simple elevated terrain
- plume impaction in complex terrain using VALLEY model 24-hr screening procedure
- building downwash (only for flat and simple elevated terrain)
- cavity region concentrations
- inversion break-up fumigation (only for rural inland sites with stack heights greater than or equal to 10 m and flat terrain)
- shoreline fumigation (for sources within 3,000 m from a large body of water)
- plume rise for flare releases

### *2.10.2 Valley Screening*

The Valley model is designed to simulate a specific worst-case condition in complex terrain, namely that of a plume impaction on terrain under stable atmospheric conditions. The algorithms of the VALLEY model are included in other models such as SCREEN3 and their use is recommended in place of the VALLEY model. The usefulness of the VALLEY model and its algorithms is limited to pollutants for which only long-term average concentrations are required. For more information on the Valley model consult the user's guide (Burt, 1977).

*Regulatory Options*

Regulatory application of the Valley model requires the setting of the following values during a model run:

- Class F Stability (rural) and Class E Stability (urban)
- Wind Speed = 2.5 m/s
- 6 hours of occurrence of a single wind direction (not exceeding a 22.5 deg sector)
- 2.6 stable plume rise factor

### *2.10.3 CTSCREEN*

The CTSCREEN model (Perry et al., 1990) is the screening mode of the Complex Terrain Dispersion Model (CTDMPLUS). CTSCREEN can be used to model single point sources only. It may be used in a screening mode for multiple sources on a case by case basis in consultation with the District. CTSCREEN is designed to provide conservative, yet theoretically more sound, worst-case 1-hour concentration estimates for receptors located on terrain above stack height. Internally-coded time-scaling factors are applied to obtain other averages (see Table 2.8). These factors were developed by comparing the results of simulations between CTSCREEN and CTDMPLUS for a variety of scenarios and provide conservative estimates (Perry et al., 1990). CTSCREEN produces identical results as CTDMPLUS if the same meteorology is used in both models. CTSCREEN accounts for the three-dimensional nature of the plume and terrain interaction and requires detailed terrain data representative of the modeling domain. A summary of the input parameters required to run CTSCREEN is given in Table 2.9. The input parameters are provided in three separate text files. The terrain topography file (TERRAIN) and the receptor information file (RECEPTOR) may be generated with a preprocessor that is included in the CTSCREEN package. In order to generate the terrain topography file the analyst must have digitized contour information.

**Table 2.8. Time-scaling factors internally coded in CTSCREEN**

| Averaging Period | Scaling Factor |
|---|---|
| 3 hours | 0.7 |
| 24 hour | 0.15 |
| Annual | 0.03 |

**Table 2.9. Input Parameters Required to Run CTSCREEN**

| Parameter | File |
|---|---|
| Miscellaneous program switches | CTDM.IN |
| Site latitude and longitude (degrees) | CTDM.IN |
| Site TIME ZONE | CTDM.IN |
| Meteorology Tower Coordinates (user units) | CTDM.IN |
| Source Coordinates: x and y (user units) | CTDM.IN |
| Source Base Elevation (user units) | CTDM.IN |
| Stack Height (m) | CTDM.IN |
| Stack Diameter (m) | CTDM.IN |
| Stack Gas Temperature (K) | CTDM.IN |
| Stack Gas Exit Velocity (m/s) | CTDM.IN |
| Emission Rate (g/s) | CTDM.IN |
| Surface Roughness for each Hill (m) | CTDM.IN |
| Meteorology: Wind Direction (optional) | CTDM.IN |
| Terrain Topography | TERRAIN |
| Receptor Information (coordinates and associated hill number) | RECEPTOR |

### *2.10.4 SHORTZ*

SHORTZ utilizes a special form of the steady-state Gaussian plume formulation for urban areas in flat or complex terrain to calculate ground-level ambient air concentrations. It can calculate 1-hour, 2-hour, 3-hour, etc., average concentrations due to emissions from stacks, buildings, and areas sources from up to 300 arbitrarily placed sources. Only a mainframe version of SHORTZ is available and its use has greatly diminished in favor of other PC-compatible models. For more information on SHORTZ consult the user's guide (Bjorklund and Bowers, 1982).

<u>*Special Cases*</u>

- Deposition
  Same algorithms as those included in ISC models with a reflection coefficient equal to zero.

### *2.10.5 LONGZ*

LONGZ contains the same algorithms found in the SHORTZ model (see Section 2.10.4) but it is designed to handle meteorology in a manner more suitable to long-term concentration estimates. LONGZ requires meteorological data in the form of STAR summaries. For more information on LONGZ consult the user's guide (Bjorklund and Bowers, 1982).

### *2.10.6 RTDM*

The RTDM screening technique can provide a more refined concentration estimate if on-site wind speed and direction, characteristic of plume dilution and transport, are used as input to the model. In complex terrain, these winds can seldom be estimated accurately from the standard surface (10 m level) measurements. Therefore, in order to increase confidence in model estimates, U.S. EPA recommends that wind data input to RTDM should be based on fixed measurements at stack top height. For stacks greater than 100 m, the measurement height may be limited to 100 m in height relative to stack base. However, for very tall stacks (e.g., greater than 200 m), the District should be consulted to determine an appropriate measurement height. This recommendation is broadened to include wind data representative of plume transport height where such data are derived from measurements taken with remote sensing devices such as SODAR. The data from both fixed and remote measurements should meet quality assurance and recovery rate requirements. The user should also be aware that RTDM in the screening mode accepts the input of measured wind speeds at only one height. The default values for the wind speed profile exponents shown in Table 2.10 are used in the model to determine the wind speed at other heights. RTDM uses wind speed at stack top to calculate the plume rise and the critical dividing streamline height, and the wind speed at plume transport level to calculate dilution. RTDM treats wind direction as constant with height.

RTDM makes use of the "critical dividing streamline" concept and thus treats plume interactions with terrain quite differently from other models such as SHORTZ and COMPLEX I. The plume height relative to the critical dividing streamline determines whether the plume impacts the terrain, or is lifted up and over the terrain. The receptor spacing to identify maximum impact concentrations is quite critical depending on the location of the plume in the vertical. Analysis of the expected plume height relative to the height of the critical dividing streamline should be performed for differing meteorological conditions in order to help develop an appropriate array of receptors. Then it is advisable to model the area twice according to the suggestions in Section 2.6.

***Table 2.10. Preferred Options for the RTDM Computer Code When Used in a Screening Mode (U.S. EPA, 1986).***

| Parameter | Variable | Value | Remarks |
|---|---|---|---|
| PR001-003 | SCALE | | Scale factors assuming horizontal distance is in kilometers, vertical distance is in feet, and wind speed is in meters per second |
| PR004 | ZWIND1 | Wind measurement height | See Section 5.2.1.4 |
| | ZWIND2 | Not used | Height of second anemometer |
| | IDILUT | 1 | Dilution wind speed scaled to plume height |
| | ZA | 0 (default) stack base | Anemometer-terrain height above |
| PR005 | EXPON | 0.09, 0.11, 0.12, 0.14, 0.2, 0.3 (default) | Wind profile exponents |
| PR006 | ICOEF | 3 (default) | Briggs Rural/ASME (1979) dispersion parameters |
| PR009 | IPPP | 0 (default) | Partial plume penetration; not used |
| PR010 | IBUOY | 1 (default) | Buoyancy-enhanced dispersion is used |
| | ALPHA | 3.162 (default) coefficient | Buoyancy-enhanced dispersion |
| PR011 | IDMX | 1 (default) | Unlimited mixing height for stable conditions |
| PR012 | ITRANS | 1 (default) | Transitional plume rise is used |
| PR013 | TERCOR | 6*0.5 (default) | Plume patch correction factors |
| PR014 | RVPTG | 0.02, 0.035 (default) | Vertical potential temperature gradient values for stabilities E and F |
| PR015 | ITIPD | 1 | Stack-tip downwash is used |
| PR020 | ISHEAR | 0 (default) | Wind shear; not used |
| PR022 | IREFL | 1 (default) | Partial surface reflection is used |
| PR023 | IHORIZ | 2 (default) | Sector averaging |
| | SECTOR | 6*22.5 (default) | Using 22.5° sectors |
| PR016 to 019; 021; and 024 | IY, IZ, IRVPTG, IHVPTG;IEPS; IEMIS | 0 | Hourly values of turbulence, vertical potential temperature gradient, wind speed profile exponents, and stack emissions are not used |

## *2.11 Refined Air Dispersion Models*

Refined air dispersion models are designed to provide more representative concentration estimates than screening models. In general, the algorithms of refined models are more robust and have the capability to account for site-specific meteorological conditions. Specific information about the refined models presented in Table 2.2 is provided in the following subsections. For more information regarding general aspects of model selection see Section 2.9.

### *2.11.1 ISCST3*

The ISCST3 model (U.S. EPA, 1995b) is a steady-state Gaussian plume model which can be used to assess pollutant concentrations from a wide variety of sources associated with an industrial source complex. The ISCST3 model can be used for multiple sources in urban or rural terrain. The model includes the algorithms of the complex terrain model COMPLEX I. The user can specify if calculations are to be made for simple terrain, complex terrain or both. However since COMPLEX 1 is a screening model, the ISCST3 model is only a screening tool for receptors in complex terrain. The ISCST3 model can calculate concentration averages for 1-hour or for the entire meteorological data period (e.g., annual). A summary of basic input parameters needed to model a point source are shown in Table 2.11. Guidance on additional input requirements, e.g., for area and volume sources, may be found in the ISC Users Guide.

***Table 2.11. Basic Input Parameters Required to Model a Point Source Using ISCST3.***

| | |
|---|---|
| Land Use | Urban or Rural |
| Averaging Period | |
| Emission Rate (g/s) | |
| Stack Height (m) | |
| Stack Gas Exit Temperature (K) | |
| Stack Gas Exit Velocity (m/s) | |
| Stack Diameter (m) | |
| Receptor Locations (x,y) coordinates (m) | discrete points; polar array; Cartesian array; |
| Meteorology | may be supplied by preprocessor PCRAMMET |
| Anemometer Height (m) | |

#### *2.11.1.1 Regulatory Options*

Regulatory application of the ISCST3 model requires the selection of specific switches (i.e., algorithms) during a model run. All the regulatory options can be set by selecting the DFAULT keyword. The regulatory options, automatically selected when the DFAULT keyword is used, are:

- Stack-tip downwash (except for Schulman-Scire downwash)
- Buoyancy-induced dispersion (except for Schulman-Scire downwash)
- Final plume rise (except for building downwash)
- Treatment of calms
- Default values for wind profile exponents
- Default values for vertical potential temperature gradients
- Use upper-bound concentration estimates for sources influenced by building downwash from super-squat buildings

#### *2.11.1.2 Special Cases*

*a. Building Downwash*

The ISC models automatically determine if the plume is affected by the wake region of buildings when their dimensions are given. The specification of building dimensions does not necessarily mean that there will be downwash. See section 2.12.1 for guidance on how to determine when downwash is likely to occur.

*b. Area Sources*

The area source algorithms in ISCST3 do not account for the area that is 1 m upwind from the receptor and, therefore, caution should be exercised when modeling very small areas with receptors placed within them or within 1 m from the downwind boundary.

*c. Volume Sources*

The volume source algorithms in ISCST3 require an estimate of the initial distribution of the emission source. Tables that provide information on how to estimate the initial distribution for different sources are given in the ISC3 User's Guide (U.S. EPA, 1995b).

*d. Intermediate Terrain*

When simple and complex terrain algorithms are selected by the user, ISCST3 will select the higher impact from the two algorithms on an hour-by-hour, source-by-source and receptor-by-receptor basis for all receptors located in intermediate terrain (U.S. EPA, 1995b).

*e. Deposition*

The ISC models contain algorithms to model settling and deposition and require additional information to do so including particle size distribution. For more information consult the ISC3 User's Guide (U.S. EPA, 1995b).

### *2.11.2 RAM*

RAM (Turner & Novak, 1978; Catalano et al., 1987) is a steady-state Gaussian model used to calculate short-term (i.e., 1-hour to 1-day) pollutant concentrations from single or multiple sources in flat or gently rolling terrain. RAM has the capability to model emissions from point and area sources in urban or rural areas. A total of 250 point sources and 100 area sources may be modeled in one single run. RAM provides several options to control the amount of information that is output by the program. A summary of input parameters is given in Table 2.12.

***Table 2.12. Input Parameters Required to Run RAM.***

| |
|---|
| *For Point Sources:* |
| Source coordinates; x and y (user units) |
| Emission rate (g/s) |
| Source Height (m) |
| Stack Diameter (m) |
| Stack Gas Exit Velocity (m/s) |
| Stack Gas Exit Temperature (K) |
| Receptors (x.y) coordinates (user units) [program can generate an array in polar coordinates or honeycomb configuration] |
| Meteorology: hourly data [may be provided with preprocessor RAMMET] |
| *For Area Sources:* |
| South-West corner coordinates of Area; x and y (user units) |
| Source Side Length (user units) |
| Total Area Emission Rate (g/s) |
| Effective Area Source height (m) |
| Receptors (x.y) coordinates (user units) [program can generate an array in polar coordinates or honeycomb configuration] |
| Meteorology: hourly data [may be provided with preprocessor RAMMET] |

#### *2.11.2.1 Regulatory Application*

Regulatory application of the RAM model requires the specification of certain program options (i.e., parameters). All of the regulatory parameters can be set using the DEFAULT option (i.e., setting IOPT(38)=1). The DEFAULT switch automatically selects the following:

- final plume rise and momentum plume rise
- buoyancy-induced dispersion
- stack-tip downwash
- treatment of "calms"
- default wind profile exponents

### *2.11.5 CTDMPLUS*

CTDMPLUS is a Gaussian air quality model for use in all stability conditions in complex terrain. In comparison with other models, CTDMPLUS requires considerably more detailed meteorological data and terrain information that must be supplied using specifically designed preprocessors.

CTDMPLUS was designed to handle up to 40 point sources.

## *2.12 Modeling Special Cases*

Special situations arise in modeling some sources that require considerable professional judgment; a few of which are outlined below. It is recommended that the reader consider retaining professional consultation services if the procedures are unfamiliar.

### *2.12.1 Building Downwash*

The entrainment of a plume in the wake of a building can result in the "downwash" of the plume to the ground. This effect can increase the maximum ground-level concentration downwind of the source. Therefore, each source must be evaluated to determine whether building downwash is a factor in the calculation of maximum ground-level concentrations. Furthermore, building downwash contributions are not automatically calculated in the cavity region of a building by most models and an underestimate of the health risk can occur in the immediate wake region of a structure. In such cases, consideration should be given to use of the 'wake cavity' feature of a model such as SCREEN3 to estimate concentrations in the cavity.

For regulatory application, a building is close enough to be considered for aerodynamic downwash if the distance from the source to the building is less than, or equal to, five times the lesser of the building height or its projected width (U.S. EPA, 1985b).

For direction-specific wind, a building is considered close enough for downwash to occur if the source is within a rectangle composed of two lines perpendicular to the wind direction, one at 5L downwind of the building and the other at 2L upwind from the building, and by two lines parallel to the wind direction at ½L away from each side of the building as shown below (where L is the lesser of the building height or its projected width). See Figure 2.

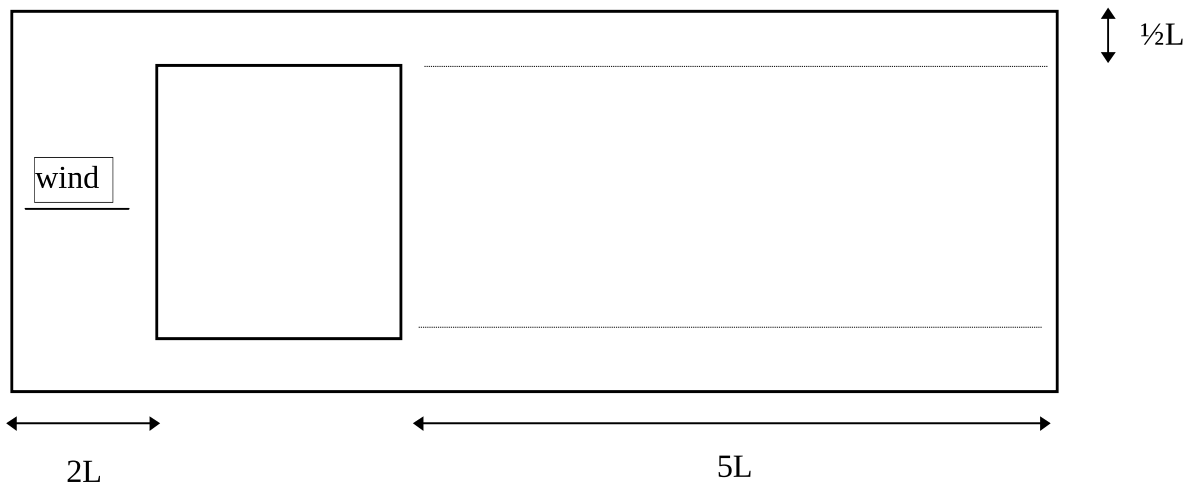


***Figure 2. Area Affected by the Building Used to Determine Whether Building Downwash Needs to be Considered (L is the lesser of the building height or its projected width). Figure is not drawn to scale.***

Complicated situations involving more than one building may necessitate the use of the Building Profile Input Program (BPIP) which can be used to generate the building dimension section of the input file of the ISC models (U.S. EPA, 1993). The BPIP program calculates each building's direction-specific projected width.

### *2.12.2 Deposition*

Several air dispersion models can provide downwind concentration estimates that take into account the upwind deposition of pollutants to surfaces and the consequential reduction of mass remaining in the plume (e.g., ISCST3). However, air dispersion models having deposition and plume depletion algorithms require particle distribution data that are not always readily available. Consequently, depletion of pollutant mass from the plume often is not taken into account.

There are two types of deposition; wet deposition and dry deposition. Wet deposition is the incorporation of gases and particles into rain-, fog- or cloud water followed by a precipitation event and also rain scavenging of particles during a precipitation event. Wet deposition of gases is therefore more important for water soluble chemicals; particles (and hence particle-phase chemicals) are efficiently removed by precipitation events (Bidleman, 1988). Dry deposition refers to the removal of gases and particles from the atmosphere

Multipathway risk assessment analyses normally incorporate deposition to surfaces in a screening mode, specifically, by assigning a default deposition velocity of 2 cm/s for controlled sources and 5 cm/s for uncontrolled sources in lieu of actual measured size distributions (ARB, 1989). For particles (and particle-phase chemicals) the deposition velocity depends on particle size and is a minimal for particles of diameter approximately 0.1-1 micrometer; smaller and larger particles are removed more rapidly.

In the Air Toxics "Hot Spots" program, deposition is modeled for particle-bound pollutants and not gases. Wet deposition of water-soluble gas phase chemicals is thus not considered. When calculating pollutant mass deposited to surfaces without including depletion of pollutant mass from the plume, an inconsistency occurs in the way deposition is treated in the risk analysis, specifically, airborne concentrations remaining in the plume and deposition to surfaces can both be overestimated, thereby resulting in overestimates of both the inhalation and multi-pathway risk estimates. However, neglecting deposition in the air dispersion model, while accounting for it in the multi-pathway health risk assessment, is a conservative, health protective approach (CAPCOA, 1987; Croes, 1988). Misapplication of plume depletion can also lead to possible underestimates of multi-pathway risk and for that reason no depletion is the default assumption. If plume depletion is incorporated, then some consideration for possible resuspension is warranted. An alternative modeling methodology accounting for plume depletion can be discussed with the Air District and used in an approved modeling protocol.

### *2.12.3 Short Duration Emissions*

Short-duration emissions (i.e., much less than an hour) require special consideration. In general, "puff models" provide a better characterization of the dispersion of pollutants having short-duration emissions. Continuous Gaussian plume models have traditionally been used for averaging periods as short as about 10 minutes and are not recommended for modeling sources having shorter continuous emission duration.

### *2.12.4 Fumigation*

Fumigation occurs when a plume that was originally emitted into a stable layer in the atmosphere is mixed rapidly to ground-level when unstable air below the plume reaches plume level. Fumigation can cause very high ground-level concentrations. Typical situations in which fumigation occurs are:

- Breaking up of a nocturnal radiation inversion by solar warming of the ground surface (rising warm unstable air); note that the break-up of a nocturnal radiation inversion is a short-lived event and should be modeled accordingly.

- Shoreline fumigation caused by advection of pollutants from a stable marine environment to an unstable inland environment

- Advection of pollutants from a stable rural environment to a turbulent urban environment

It should be noted that currently SCREEN3 is the only U.S. EPA guideline model that incorporates fumigation, and it is limited to maximum hourly evaluations.

### *2.12.5 Raincap on Stack*

The presence of a raincap or any obstacle at the top of the stack hinders the momentum of the exiting gas. Therefore, assuming that the gas exit velocity would be the same as the velocity in a stack without an obstacle is an improper assumption. The extent of the effect is a function of the distance from the stack exit to the obstruction and of the dimensions and shape of the obstruction.

On the conservative side, the stack could be modeled as having a non-zero, but negligible exiting velocity, effectively eliminating any momentum rise. Such an approach would result in final plume heights closer to the ground and therefore higher concentrations nearby. There are situations where such a procedure might lower the actual population-dose and a comparison with and without reduced exit velocity should be examined.

Plume buoyancy is not strongly reduced by the occurrence of a raincap. Therefore if the plume rise is dominated by buoyancy, it is not necessary to adjust the stack conditions. (The air dispersion models determine plume rise by either buoyancy or momentum, whichever is greater.)

The stack conditions should be modified when the plume rise is dominated by momentum and in the presence of a raincap or a horizontal stack. Sensitivity studies with the SCREEN3 model, on a case-by-case basis, can be used to determine whether plume rise is dominated by buoyancy or momentum. The District should be consulted before applying these procedures.

- Set exit velocity to 0.001 m/sec
- Turn stack tip downwash off
- Reduce stack height by 3 times the stack diameter

Stack tip downwash is a function of stack diameter, exit velocity, and wind speed. The maximum stack tip downwash is limited to three times the stack diameter in the ISC3 air dispersion model. In the event of a horizontal stack, stack tip downwash should be turned off and no stack height adjustments should be made.

Note: This approach may not be valid for large (several meter) diameter stacks.

An alternative, more refined, approach could be considered for stack gas temperatures which are slightly above ambient (e.g., ten to twenty degrees Fahrenheit above ambient). In this approach, the buoyancy and the volume of the plume remains constant and the momentum is minimized.

- Turn stack tip downwash off
- Reduce stack height by 3 times the stack diameter ($3D_o$)
- Set the stack diameter ($D_b$) to a large value (e.g., 10 meters)
- Set the stack velocity to $V_b = V_o (D_o/D_b)^2$

Where $V_o$ and $D_o$ are the original stack velocity and diameter and $V_b$ and $D_b$ are the alternative stack velocity and diameter for constant buoyancy. This approach is advantageous when $D_b >> D_o$ and $V_b << V_o$ and should only be used with District approval.

### *2.12.6 Landfill Sites*

Landfills should be modeled as area sources. The possibility of non-uniform emission rates throughout the landfill area should be investigated. A potential cause of non-uniform emission rates would be the existence of cracks or fissures in the landfill cap (where emissions may be much larger). If non-uniform emissions exist, the landfill should be modeled with several smaller areas assigning an appropriate emission factor to each one of them, especially if there are nearby receptors (distances on the same order as the dimensions of the landfill).

## *2.13 Specialized Models*

Some models have been developed for application to very specific conditions. Examples include models capable of simulating sources where both land and water surfaces affect the dispersion of pollutants and models designed to simulate emissions from specific industries.

### *2.13.1 Buoyant Line and Point Source Dispersion Model (BLP)*

BLP is a Gaussian plume dispersion model designed for the unique modeling problems associated with aluminum reduction plants, and other industrial sources where plume rise and downwash effects from stationary line sources are important.

#### *2.13.1.1 Regulatory Application*

Regulatory application of BLP model requires the selection of the following options:

- rural (IRU=l) mixing height option;

- default (no selection) for all of the following: plume rise wind shear (LSHEAR), transitional point source plume rise (LTRANS), vertical potential temperature gradient (DTHTA), vertical wind speed power law profile exponents (PEXP), maximum variation in number of stability classes per hour (IDELS), pollutant decay (DECFAC), the constant in Briggs' stable plume rise equation (CONST2), constant in Briggs' neutral plume rise equation (CONST3), convergence criterion for the line source calculations (CRIT), and maximum iterations allowed for line source calculations (MAXIT); and

- terrain option (TERAN) set equal to 0.0, 0.0, 0.0, 0.0, 0.0, 0.0

For more information on the BLP model consult the user’s guide (Schulman and Scire, 1980).

### *2.13.2 Offshore and Coastal Dispersion Model (OCD)*

OCD (DiCristofaro and Hanna, 1989) is a straight-line Gaussian model developed to determine the impact of offshore emissions from point, area or line sources on the air quality of coastal regions. OCD incorporates “over-water” plume transport and dispersion as well as changes that occur as the plume crosses the shoreline. Hourly meteorological data are needed from both offshore and onshore locations. Additional data needed for OCD are water surface temperature, over-water air temperature, mixing height, and relative humidity.

Some of the key features include platform building downwash, partial plume penetration into elevated inversions, direct use of turbulence intensities for plume dispersion, interaction with the overland internal boundary layer, and continuous shoreline fumigation.

#### *2.13.2.1 Regulatory Application*

OCD has been recommended for use by the Minerals Management Service for emissions located on the Outer Continental Shelf (50 FR 12248; 28 March 1985). OCD is applicable for over-water sources where onshore receptors are below the lowest source height. Where onshore receptors are above the lowest source height, offshore plume transport and dispersion may be modeled on a case-by-case basis in consultation with the District.

### *2.13.3 Shoreline Dispersion Model (SDM)*

SDM (PEI, 1988) is a hybrid multipoint Gaussian dispersion model that calculates source impact for those hours during the year when fumigation events are expected using a special fumigation algorithm and the MPTER regulatory model for the remaining hours.

SDM may be used on a case-by-case basis for the following applications:

- tall stationary point sources located at a shoreline of any large body of water;
- rural or urban areas;
- flat terrain;
- transport distances less than 50 km;
- 1-hour to 1-year averaging times.

## *2.14 Interaction with the District*

The risk assessor must contact the District to determine if there are any specific requirements. Examples of such requirements may include: specific receptor location guidance, specific usage of meteorological data and specific report format (input and output).

### *2.14.1 Submittal of Modeling Protocol*

It is strongly recommended that a modeling protocol be submitted to the District for review and approval prior to extensive analysis with an air dispersion model. The modeling protocol is a plan of the steps to be taken during the air dispersion modeling process. Following is an example of the format that may be followed in the preparation of the modeling protocol. Consult with the District to confirm format and content requirements or to determine the availability of District modeling guidelines before submitting the protocol.

*Emissions*

- Specify that emission estimates for all substances for which emissions were required to be quantified will be included in the risk assessment. This includes both annual average emissions and maximum one-hour emissions of each pollutant from each process.

- Specify the format in which the emissions information will be provided (consult with the District concerning format prior to submitting the protocol).

- Specify the basis for using emissions data, other than that included in the previously submitted emission inventory report, for the risk assessment (consult with the District concerning the use of updated emissions data prior to submitting the protocol).

- Specify the format for presenting release parameters (e.g., stack height and diameter, stack gas exit velocity, release temperature) for each process as part of the risk assessment (consult with the District concerning the format prior to submitting the protocol).

- A revised emission inventory report must be submitted to the District and forwarded by the District to the CARB if revised emission data are used.

*Models*

- Identify the model(s) to be used, including the version number.

- Identify any additional models to be run if receptors are found above stack height.

- Specify which model results will be used for receptors above stack height.

- Specify the format for presenting the model options selected for each run (consult with the District concerning the format prior to submitting the protocol).

*Meteorological Data*

- Specify type, source, and year (e.g., hourly surface data, upper air mixing height information).

- Evaluate whether the data are representative.

- Describe QA/QC procedures.

- Identify any gaps in the data; if so, describe how the data gaps are filled.

*Deposition*

- Specify method to calculate deposition (if applicable).

*Receptors*

- Identify the method to determine maximum exposed individual for residential and occupational areas for long-term exposures (e.g., a Cartesian grid and 100-meter grid increments).

- Identify method to determine maximum short-term impact.

- Identify method to evaluate cancer risk in the vicinity of the facility for purposes of calculating cancer burden (e.g., centroids of the census tracts in the area within the zone of impact).

- Specify that UTM coordinates and street addresses, where possible, will be provided for specified receptor locations.

*Maps*

- Specify which cancer risk isopleths will be plotted (e.g., 10-6, 10-7; see Section 2.6.1).

- Specify which hazard indices will be plotted for acute and chronic (e.g., 0.1, 1, 10).

## *2.15 Report Preparation*

This section describes the information related to the air dispersion modeling process that needs to be reported in the risk assessment. The District may have specific requirements regarding format and content (see Section 2.14). Sample calculations should be provided at each step to indicate how reported emissions data were used. It is helpful for the reviewing agencies to receive input, output, and supporting files of various model analyses on computer-readable media (e.g., CD, disk).

### *2.15.1 Information on the Facility and its Surroundings*

Report the following information regarding the facility and its surroundings:

- Facility Name
- Location (UTM coordinates and street address)
- Land use type (see Section 2.4)
- Local topography
- Facility plot plan identifying:
    - source locations
    - property line
    - horizontal scale
    - building heights
    - emission sources

### *2.15.2 Source and Emission Inventory Information*†

*Source Description and Release Parameters*

Report the following information for each source in table format:

- Source identification number used by the facility
- Source name
- Source location using UTM coordinates
- Source height (m)
- Source dimensions (e.g., stack diameter, building dimensions, area size) (m)
- Exhaust gas exit velocity (m/s)
- Exhaust gas volumetric flow rate (ACFM)
- Exhaust gas exit temperature (K)

See Appendix J form RAG-003 for an example of a table.

*Source Operating Schedule*

The operating schedule for each source should be reported in table form including the following information:

- Number of operating hours per day and per year (e.g., 0800-1700, 2700 hr/yr)
- Number of operating days per week (e.g., Mon-Sat)
- Number of operating days or weeks per year (e.g., 52 wk/yr excluding major holidays)

See Appendix J form RAG-004 for an example.

*Emission Control Equipment and Efficiency*

Report emission control equipment and efficiency by source and by substance

*Emissions Data Grouped By Source*

Report emission rates for each toxic substance, grouped by source (i.e., emitting device or process identified in Inventory Report), in table form including the following information (see Appendix J Form RAG-001):

- Source name
- Source identification number
- Substance name and CAS number (from Inventory Guidelines)
- Annual average emissions for each substance (lb/yr)
- Hourly maximum emissions for each substance (lb/hr)

*Emissions Data Grouped by Substance*

Report facility total emission rate by substance for all emitted substances listed in the Air Toxics “Hot Spots” Program including the following information (see Appendix J Form RAG-002):

- Substance name and CAS number (from Inventory Guidelines)
- Annual average emissions for each substance (lb/yr)
- Hourly maximum emissions for each substance (lb/hr)

*Emission Estimation Methods*

Report the methods used in obtaining the emissions data indicating whether emissions were measured or estimated. Clearly indicate any emission data that are not reflected in the previously submitted emission inventory report and submit a revised emission inventory report to the district. A reader should be able to reproduce the risk assessment without the need for clarification.

*List of Substances*

Include tables listing all "Hot Spots" Program substances which are emitted, plus any other substances required by the District. Indicate substances to be evaluated for cancer risks and noncancer effects.

### *2.15.3 Exposed Population and Receptor Location*

- Report the following information regarding exposed population and receptor locations:

- Description of zone of impact including map showing the location of the facility, boundaries of zone of impact, census tracts, emission sources, sites of maximum exposure, and the location of all appropriate receptors. This should be a true map (one that shows roads, structures, etc.), drawn to scale, and not just a schematic drawing. USGS 7.5 minute maps are usually the most appropriate choice. (If significant development has occurred since the user's survey, this should be indicated.)
- Separate maps for the cancer risk zone of impact and the hazard index (noncancer) zone of impact. The cancer zone of impact should include isopleths down to at least the 1/1,000,000 risk level. Because some districts use a level below 1/1,000,000 to define the zone of impact, the District should be consulted. Two separate isopleths (to represent both chronic and acute HHI) should be created to define the zone of impact for the hazard index from both inhalation and noninhalation pathways greater than or equal to 1.0. The point of maximum impact (PMI), maximum exposed individual at a residential receptor(MEIR), and maximum exposed individual worker (MEIW) for both cancer and noncancer risks should be located on the maps.
- Tables identifying population units and sensitive receptors (UTM coordinates and street addresses of specified receptors)
- Heights or elevations of the receptor points

### *2.15.4 Meteorological Data*

If meteorological data were not obtained directly from the District, the report must clearly indicate the source and time period used. Meteorological data not obtained from the District must be submitted in electronic form along with justification for their use including information regarding representativeness and quality assurance.

The risk assessment should indicate if the District required the use of a specified meteorological data set. All memos indicating the District's approval of meteorological data should be attached in an appendix.

### *2.15.5 Model Selection and Modeling Rationale*

The report should include an explanation of the model chosen to perform the analysis and any other decisions made during the modeling process. The report should clearly indicate the name of the models that were used, the level of detail (screening or refined analysis) and the rationale behind the selection.

Also report the following information for each air dispersion model used:

- version number
- selected options and parameters in table form

### *2.15.6 Air Dispersion Modeling Results*

- Maximum hourly and annual average concentrations of chemicals at appropriate receptors such as the residential and worker MEI receptors
- Annual average and maximum one-hour (and 30-day average for lead only‡) concentrations of chemicals at appropriate receptors listed and referenced to computer printouts of model outputs
- Model printouts (numbered), annual concentrations, maximum hourly concentrations
- Disk with input/output files for air dispersion program (e.g., the ISCST3 input file containing the regulatory options and emission parameters, receptor locations, meteorology, etc.)
- Include tables that summarize the annual average concentrations that are calculated for all the substances at each site. The use of tables that present the relative contribution of each emission point to the receptor concentration is recommended. (These tables should have clear reference to the computer model which generated the data. It should be made clear to any reader how data from the computer output was transferred to these tables.) [As an alternative, the above two tables could contain just the values for sites of maximum impact (i.e., PMI, MEIR and MEIW), and sensitive receptors, if required. All the values would be found in the Appendices.]

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(†) Health and Safety Code section 44346 authorizes facility operators to designate certain "Hot Spots" information as trade secret. Section 44361(a) requires districts to make health risk assessments available for public review upon request. Section 44346 specifies procedures to be followed upon receipt of a request for the release of trade secret information. See also the Inventory Guidelines Report regarding the designation of trade secret information in the Inventory Reports.

(‡)Please contact the Office of Environmental Health Hazard Assessment for information on calculating and presenting subchronic lead results.

## *2.16 References*

Auer Jr., A.H. (1978). Correlation of Land Use and Cover with Meteorological Anomalies. *Journal of Applied Meteorology*, 17:(5):636-643.

ARB (1994). ARB memorandum dated 4/11/94 from A. Ranzieri to J. Brooks on the subject, "One-hour to Thirty-day Average Screening Factor."

ARB (1989). "Screening Deposition Velocities," Internal memorandum from A. Ranzieri to G. Shiroma dated 8/17/89.

T. F. Bidleman, "Atmospheric processes", Environmental Science & Technology, 22, pp. 361-367 (1988)

Bjorklund, J.R. and J.F. Bowers (1982). User's Instructions for the SHORTZ and LONGZ Computer Programs, Volumes I and II. EPA-903/9-82-004A and B. U.S. Environmental Protection Agency. Philadelphia, PA.

Burt, E.W. (1977). Valley Model User's Guide. EPA-450/2-77-018. U.S. Environmental Protection Agency, Research Triangle Park, NC.

CAPCOA (1987). "Deposition Rate Calculations for Air Toxics Source Assessments," in Air Toxics Assessment Manual, Appendix C.7.

Catalano, J.A., D.B. Turner and H. Novak (1987). User's Guide for RAM - Second Edition. U.S. Environmental Protection Agency. Research Triangle Park, NC. (Distributed as part of UNAMAP Version 6 Documentation)

Chico, T. and J. A. Catalano (1986). Addendum to the User's Guide for MPTER. U. S. Environmental Protection Agency. Research Triangle Park, NC.

Croes, B. (1988). "Deposition Rate Calculations for Air Toxic Risk Assessments in California," Proceedings of the 81st Annual Meeting of the Air Pollution Control Association, Dallas, TX, June 20-24, 1988.

DiCristofaro, D. C. and S. R. Hanna (1989). OCD: The Offshore and Coastal Dispersion Model, Version 4. Volume I: User's Guide, and Volume II: Appendices. Sigma Research Corporation, Westford, MA. (NTIS Nos. PB 93-144384 and PB 93-144392)

Irwin, J.S. (1978). Proposed Criteria for Selection of Urban Versus Rural Dispersion Coefficients. (Draft Staff Report). Meteorology and Assessment Division. U.S. Environmental Protection Agency, Research Triangle Park, NC. (Docket No. A-80-46, II-B-8).

PEI Associates (1988). User's Guide to SDM - A Shoreline Dispersion Model. U.S. EPA Publication No. EPA-450/4-88-017. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Perry, S.G., D.J. Burns, A.J. Cimorelli (1990). User's Guide to CTDMPLUS: Volume 2. The Screening Mode (CTSCREEN). EPA-600/8-90-087. Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC.

Pierce, T.E., D.B. Turner, J.A. Catalano, and F.V. Hale (1982). PTPLU - A Single Source Gaussian Dispersion Algorithm User's Guide. EPA-600-/8-82-014. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Pierce, T.E. (1986). Addendum to PTPLU - A Single Source Gaussian Dispersion Algorithm. EPA/600/8-86-042. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Schulman, L.L., and J.S. Scire (l980). Buoyant Line and Point Source (BLP) Dispersion Model User's Guide. Document P-7304B. Environmental Research and Technology, Inc., Concord, MA. (NTIS No. PB 8l-l64642)

Tikvart, J. (1993). "Proposal for Calculating Plume Rise for Stacks with Horizontal Releases or Rain Caps for Cookson Pigment, Newark, New Jersey," Internal memorandum from J. Tikvart to K. Eng dated 7/9/93.

Turner, D. and J.H. Novak (1978). User's Guide for RAM. Vol. 1. Algorithm Description and Use, Vol. II. Data Preparation and Listings. EPA-600/8-78-016a and b. U.S. Environmental Protection Agency, Research Triangle Park, NC.

U.S. EPA (1984a). Calms Processor (CALMPRO) User's Guide. EPA-901/9-84-001. U.S. Environmental Protection Agency, Region I, Boston, MA.

U.S. EPA (1984b). Interim Procedures for Evaluating Air Quality Models (Revised). EPA-450/4-84-023. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 85-106060)

U.S. EPA (1985a). Interim Procedures for Evaluating Air Quality Models: Experience with Implementation. U.S. EPA Publication No. EPA-450/4-85-006. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 85-242477)

U.S. EPA (1985b). Guideline for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations) - Revised EPA-450/4-80-023R, U.S. Environmental Protection Agency, Research Triangle Park, NC.

U.S. EPA (1986). Guideline on Air Quality Models (Revised). EPA 450/2-78-027R. U.S. Environmental Protection Agency, Research Triangle Park, NC.

U.S. EPA (1992). Protocol for Determining the Best Performing Model. U.S. EPA Publication No. EPA-454/R-92-025. U.S. Environmental Protection Agency, Research Triangle Park, NC.

U.S. EPA (1993). User's Guide to the Building Profile Input Program (BPIP). Revised February, 1995. EPA-454/R-93-038. U.S. Environmental Protection Agency, Research Triangle Park, NC.

U.S. EPA (1995a). Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised. EPA-450/R-92-019. U.S. Environmental Protection Agency, Research Triangle Park, NC.

U.S. EPA (1995b). User's Guide for the Industrial Source Complex (ISC) Dispersion Models. Volume I: User Instructions. EPA-454/B-95-003a. U.S. Environmental Protection Agency, Research Triangle Park, NC.

U.S. EPA (1995c). User's Guide for the Industrial Source Complex (ISC) Dispersion Models. Volume II: User Instructions. EPA-454/B-95-003a. U.S. Environmental Protection Agency, Research Triangle Park, NC.

U.S. EPA (1995d). SCREEN3 Model User's Guide. EPA-454/B-95-004. U.S. Environmental Protection Agency. Research Triangle Park, NC.

U.S. EPA (1995e). On-Site Meteorological Program Guidance For Regulatory Modeling Applications. EPA-450/4-87-013. U.S. Environmental Protection Agency, Research Triangle Park, NC.